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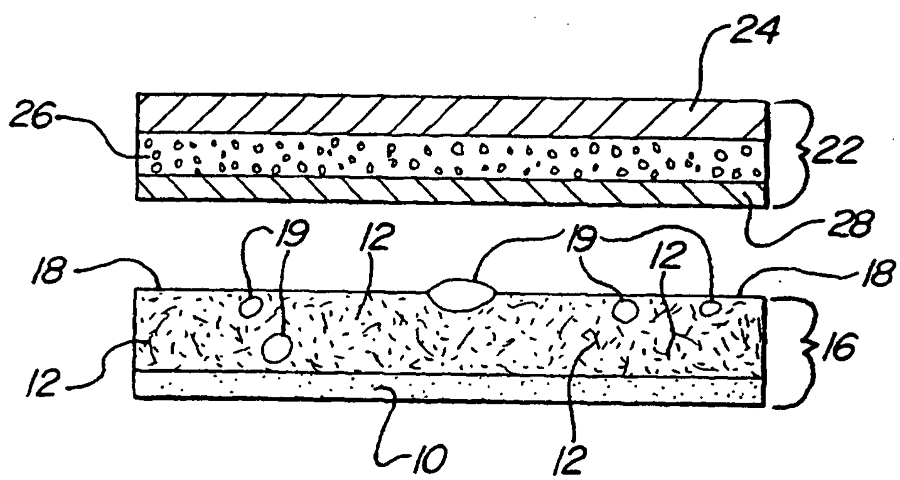
(54) Title: COUNTER-PRESSURE MOLDING OF URETHANE FOAM




(57) Abstract: A method for manufacturing a vehicle trim panel with a urethane foam using a counter or positive pressure to eliminate void defects inherent in the molding of urethane foams. During molding of the trim panel, a positive pressure is applied to the outer layer that forms the exterior or viewable surface of the trim panel to counteract the migration of air bubbles to the top surface of the urethane foam forming the core of the trim panel.

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# COUNTER-PRESSURE MOLDING OF URETHANE FOAM

## Field of the Invention

The present invention relates to a method for manufacturing vehicle trim panels. Specifically, the subject invention relates to a method of molding a trim panel using urethane foam that eliminates costly void defects that are inherent in molding of urethane foams.

## Description of the Related Art

Urethane foam molding processes for manufacturing vehicle trim panels such as headliners and vehicle door panels are generally known to those skilled in the art. For example, a vehicle headliner is typically manufactured with a forming tool or die wherein top and bottom layers are inserted into the forming tool and a urethane matrix is sprayed between the layers to form a core.

A conventional urethane foam molding process for manufacturing vehicle trim panels is generally disclosed in Figures 1 and 2. As shown best in Figure 1, a conventional urethane foam molding process is accomplished in two steps. The first step begins by inserting an anti-squeak foam backing 10 into a lower molding tool (not shown in Figs. 1-2). Next, a porous fiberglass mat 12 is placed on the foam backing 10. Continuing, urethane matrix is sprayed on the foam backing 10 and fiberglass mat 12 positioned in the lower molding tool and is dispersed within and throughout the fiberglass mat 12. After the urethane is sprayed, the urethane foams, rises, and hardens, and a urethane foam 16 is established. During the foaming and rising of the urethane, air bubbles 19 inherent to the process migrate toward a top surface 18 of the foam 16. Often, as the urethane hardens into the foam 16, the migrating air bubbles 19 are trapped within the urethane and the fiberglass mat 12. However, as the urethane foam hardens, the air bubbles 19 may be trapped at the top surface 18 of the foam 16.

Referring now to Figure 2, as a result of the air bubbles being trapped at the top surface 18 of the foam 16, a permanent void defect 20 is formed at a top surface 18 of the now hardened urethane foam 16.

Next, the second step of the conventional urethane foam molding process applies a foam backed cloth 22 to the urethane foam 16. The foam backed cloth 22 includes a cloth layer 24 and a foam layer 26. The cloth layer 24 is the outer layer that forms the exterior or

layer 24 and a foam layer 26. The cloth layer 24 is the outer layer that forms the exterior or viewable surface of the trim panel. In order to apply the foam backed cloth 22 to the urethane foam 16, an adhesive/barrier layer 28 must be included between the foam layer 26 of the foam backed cloth 22 and the urethane foam 16. As shown in Figure 2, if the top surface 18 of the urethane foam 16 includes a void defect 20, then ultimately the cloth layer 24 of the foam backed cloth 22 also realizes the same void defect 20.

Attempts to offset this realization of the void defect 20 at the cloth layer 24 where such a defect would be noticeable to occupants of a vehicle have proven to be costly. For example, one such attempt inserts a structural film to structurally mask the void defect 20 before adding the foam backed cloth 22 in the second step, which is costly and labor intensive.

Accordingly, there remains a need in the art for a method of manufacturing a trim panel that eliminates void defects resulting from air bubbles occurring in the urethane foam during the foaming of the urethane matrix.

**Summary of the Invention**

Accordingly, the present invention is a method for molding a vehicle trim panel having an exterior or outer layer and a urethane core. The method includes the steps of providing a forming tool having a core portion and a cavity portion that cooperate to form a die cavity complementary with the trim panel. The exterior or outer layer is placed in the forming tool adjacent to the mold surface of the cavity portion and a vacuum is drawn on the cavity portion to hold the exterior layer against the mold surface of the cavity portion. The method also includes the steps of providing a foamable material and applying the foamable material to the core portion of the molding tool. The forming tool is closed and the foamable material expands. The method further includes the step of applying pressure against the exterior or outer layer while the foamable material is expanding to inhibit bubbles from forming at the surface of the foamable material. Finally, the pressure is released and the forming tool is opened to remove the trim panel from the forming tool.

One advantage of the method for molding a trim panel according to the present invention is that adding pressure to the forming tool during expansion of the foamable

material controls the formation of air bubbles on the surface of the foamable material and prevents the urethane foam from penetrating the exterior or outer layer.

Further advantages of the present invention will be readily appreciated as the same becomes understood by reference to the following detailed description when considered in connection with the accompanying drawings.

**Brief Description of the Drawings**

Fig. 1 is a cross sectional side view of a conventional two-step urethane foam molding process according to the prior art;

Fig. 2 is a cross sectional side view of the conventional two-step urethane foam molding process according to the prior art illustrating the effect of a void defect formed initially at a top surface of a urethane foam;

Fig. 3 is a schematic side view showing a molding apparatus for use in forming a trim panel according to the one-step urethane foam molding process of the present invention with the mold open;

Fig. 4 is a schematic side view showing the molding apparatus of Fig. 3 for use in forming the trim panel according to the one-step urethane foam molding process of the present invention with the mold closed;

Fig. 5 is a cross sectional side view of a trim panel formed according to the one-step urethane foam molding process of the subject invention; and

Fig. 6 is a fragmentary cross sectional side view taken in the circle 6-6 of Fig. 4, showing a trim panel formed according to the one-step urethane foam molding process of the present invention and illustrating a cavity and the application of pressure being applied through the cavity to counteract formation of void defects at the top surface of the urethane foam.

**Detailed Description of the Preferred Embodiment**

Referring to the Figs. 3-6, wherein like numerals indicate like or corresponding parts throughout the several views, an apparatus for performing a one-step urethane foam molding process is shown. The one-step urethane foam molding process of the subject invention applies to both rigid and semi-rigid polyurethanes. For example, a rigid polyurethane can

be incorporated into the one-step urethane foam molding process of the subject invention to manufacture vehicle door panels. Also for example, a semi-rigid polyurethane can be incorporated into the one-step urethane foam molding process of the subject invention to manufacture vehicle headliners. For descriptive purposes, although the subject invention will be described hereinbelow only in terms of the semi-rigid polyurethane and vehicle headliners, the subject invention is not limited to such.

As shown in Figs. 3-4, the molding apparatus 30 includes a frame 32 that supports an upper mold assembly or cavity 34 of a forming tool 36. The cavity 34 has a mold surface 38 which is shaped in a configuration corresponding to that of the desired shape of the headliner. Vertical or reciprocal movement of the cavity 34 may be accomplished in a number of ways. In the present embodiment, the cavity 34 is supported on columns 40 having a rack portion. Each column is slidably secured in a housing 42. Pinion gears (not shown) engage the rack portion and are driven by a drive rod 44, which is rotated by a motor 46, to lift and lower the cavity 34.

The molding apparatus 30 further includes a fixed track 48 that extends through the frame 32, below the cavity 34. Wheel members 52 support a lower mold assembly or core 50 for movement on the track 48. Known to those skilled in the art are a number of ways to drive of the core 50 on the track 48. Secured beneath the core 50 is a steel platen 54. A plurality of tubular airbags 56 extend transversely to the track 48. In Figs. 3-4, the airbags 56 are shown inflated such that they engage the steel platen 54 and raise the wheel members 52 of the core 50 above the track 48. In this manner, see Fig. 4, the compressive load occurring during the molding process is borne by the airbags 56.

The molding apparatus 30 is shown here utilizing a core 50 movable on a fixed track 48, this is for illustration purposes only. In this embodiment, the molding apparatus 30 is provided with additional cores 50 that can be alternately moved on the track 48 under the cavity 34 during the molding operation. In such fashion, the core 50 not being used is set up or prepared for the next molding operation. It should be appreciated that the molding assembly 30 could be a single, stationary forming tool 36 having a cavity 34 and core 50.

In accordance with the present invention, as shown in Fig. 3, an anti-squeak foam backing 60 is placed on the mold surface 58 of the core 50. A porous fiberglass mat 62 is then placed over the anti-squeak foam backing 60. As part of the molding process, as outer

or exterior layer 64 placed on the cavity 34 and maintained against the mold surface 38 of the cavity 34 by a vacuum assembly 66 such that the outer or exterior layer backed cloth 64 conforms to the mold surface 38. In the preferred embodiment, the outer or exterior layer is a foam backed cloth 64. The foam backed cloth 64 includes a cloth layer 68 and an open-cell foam layer 70. As shown in Figs. 3-4, the cavity 34 contains a plurality of vacuum ports 72 extending through the cavity 34 to the mold surface 38. A vacuum channel or plenum 74 connects the vacuum ports 72 through vacuum hose 76 to a pump 78. As set forth in greater detail below, the pump 78 is capable of both generating a vacuum or negative pressure, i.e. a pressure less than atmospheric and a pressure, i.e. a positive pressure or pressure greater than atmospheric.

Concurrent with the placement of the foam backed cloth layer 64 on the cavity 34, the semi-rigid polyurethane is sprayed on and dispersed within and throughout the fiberglass mat 62 placed in the core 50. As shown in Fig. 4, the forming tool 36 is closed by lowering the cavity 34 downward into engagement with the core 50 after which the semi-rigid polyurethane begins to foam, rise, and harden. Ultimately, a semi-rigid polyurethane foam 80 is established. The foam 80 comprises a mixture of the fiberglass mat 62 and the semi-rigid polyurethane. During the foaming and rising of the semi-rigid polyurethane, air bubbles such as those shown in the prior art, Figs. 1-2, and inherent to the urethane foaming process migrate toward a top surface 82 of the foam 80. As discussed above in the Background of the Invention, if the air bubbles become trapped at the top surface 82 of the foam 80 while the semi-rigid polyurethane rises and hardens, then the air bubbles form permanent void defects in the top surface 82 of the now hardened foam 80.

As shown in Fig. 6, the one-step urethane foam molding process of the subject invention directly counteracts the migration of air bubbles to the top surface 82 of the foam 80 by applying pressure (represented by Arrows $B_1$, $B_2$, $B_3$, $B_4$, and $B_5$) to the top surface 82. As a result, the formation of permanent void defects at the top surface 82 is minimized, if not entirely eliminated. The pressure application will be discussed further hereinbelow.

As shown specifically in Fig. 5, an advantage of the one-step urethane foam molding process is realized by the elimination of an adhesive/barrier layer adjacent to the foam layer 70 of the foam backed cloth 64. Instead, the foam backed cloth 64 is directly adhered to the top surface 82 of the foam 80 by a chemical bond established between the foam layer 70 of

the foam backed cloth 64 and the semi-rigid polyurethane as it foams, rises, and hardens. Eliminating the adhesive/barrier layer obviously incorporates advantageous cost savings into the one-step urethane foam molding process.

Although not shown in the Figures, it is understood by those skilled in the art that mold release films may be incorporated at critical interfaces between the various components of the subject invention to permissibly release the completed vehicle headliner from the cavity 34 and core 50 of the forming tool 36.

As discussed above, in order to effectively counteract the formation of void defects at the top surface 82 of the foam, a gas under pressure $B_1$ - $B_5$ is applied through passageways 72. More specifically, as the semi-rigid polyurethane foams, rises, and hardens, and as the air bubbles migrate toward the top surface 82 of the rising semi-rigid polyurethane, the vacuum, originally established to maintain the foam backed cloth 36 layer in the upper molding tool 34, is reversed to now input a preferably inert gas to create a positive pressure (as shown in Figure 6) into the cavity 34 of the forming tool 36. As such, the gas under positive pressure permeates through the cloth layer 68 and the foam layer 70 of the foam backed cloth 64 to the top surface 82 of the foam 80 to discourage the air bubbles from reaching the top surface 82 and ultimately forming void defects in the foam 80. As a result, an insertion of a structural film to structurally mask any void defects is not required as the void defects are not at the top surface 82 of the foam 80. Instead, the void defects, if any, are dispersed below the top surface 82.

As appreciated, introduction of positive pressure to counteract the formation of void defects at the top surface 82 of the foam 80 preferably utilizes existing molding equipment. That is, the same ports or passageways 72 utilized to maintain the foam backed cloth 64 in the cavity 34 are the same ports 72 that are subsequently utilized to introduce a gas under a positive pressure to counter the formation of void defects.

As understood by those in the art, the relation between the cavity 34 and core 50 portions of the forming tool 36 is not critical. As a result, the one-step urethane foam molding process may interchange the operation of the cavity 34 and core 50 so long as the positive pressure introduced to counteract the formation of void defects is correspondingly interchanged.

The time interval where the vacuum maintaining the foam backed cloth 64 in the cavity 34 is changed over to positive pressure introduced into the closed cavity 34 and core 50 is important. For instance, a short time interval prior to changing from the vacuum to a positive pressure could introduce an excessive amount of air bubbles into the foaming and rising semi-rigid polyurethane and could potentially create more void defects in the foam 80. On the other hand, if the time interval is too long, then the vacuum may permit the semi-rigid polyurethane to excessively foam and rise thereby penetrating through the foam layer 70 and into the cloth layer 68 of the foam backed cloth 64. Accordingly, it is desirable to apply a positive or counter-pressure during expansion of the foam at a pressure level necessary to prevent the foam 80 from expanding into the open-cell foam layer 70 of the foam backed cloth 64.

By way of example, a headliner can be manufactured utilizing the present invention with a 125 second cycle time. Once the mold is closed, the foam 80 is allowed to expand for a period of 25 seconds. The expanding foam will create a pressure in the mold of about 32 psi. For the next 100 seconds, air is injected into the mold through passageways 72 to achieve a pressure in the closed cavity 34 of about 45 psi.

The invention has been described in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation. Many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that the invention may be practiced otherwise as specifically described.

What is claimed is:

1. A method of molding a vehicle trim panel comprising the steps of:

providing a forming tool having a core portion and a cavity portion, said cavity portion having fluid passageways;

providing an outer layer forming an outer portion of the trim panel and placing the outer layer in the forming tool adjacent to a mold surface of the cavity portion;

drawing a vacuum through the fluid passageways to hold the outer layer against the mold surface of the cavity portion;

providing a foamable material and applying the foamable material to the core portion of the molding tool;

closing the forming tool;

allowing the foamable material to expand;

applying a gas under pressure through the fluid passageways while the foamable material is expanding; and

releasing the pressure, opening the forming tool and removing the trim panel from the forming tool.

2. A method according to claim 1 wherein said step of applying pressure includes continuing to apply pressure until the foamable material hardens.

3. A method according to claim 1 wherein the outer layer includes a cloth layer and an open-cell foam layer and wherein said step of applying pressure includes applying pressure through the cloth layer and into the open-cell layer at a level that prevents the foamable material from penetrating the open-cell layer.

4. A method of molding a vehicle trim panel comprising the steps of:

providing a forming tool having a core portion and a cavity portion, said core portion having fluid passageways;

providing an outer layer forming an outer portion of the trim panel and placing the outer layer in the forming tool adjacent to a mold surface of the core portion;

drawing a vacuum through the passageways to hold the outer layer against the mold surface of the core portion;

providing a foamable material and applying the foamable material to the cavity portion of the molding tool;

closing the forming tool;

allowing the foamable material to expand;

applying a gas under pressure through the passageways while the foamable material is expanding; and

releasing the pressure, opening the forming tool and removing the trim panel from the forming tool.

5. A method according to claim 4 wherein said step of applying pressure includes continuing to apply pressure until the foamable material hardens.

6. A method according to claim 4 wherein the outer layer includes a cloth layer and an open-cell foam layer and wherein said step of applying pressure includes applying pressure through the cloth layer and into the open-cell layer at a level that prevents the foamable material from penetrating the open-cell layer.

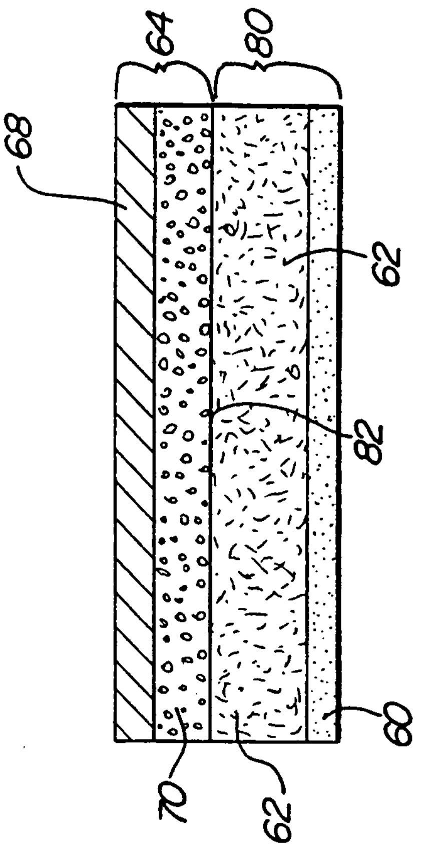


FIG-5

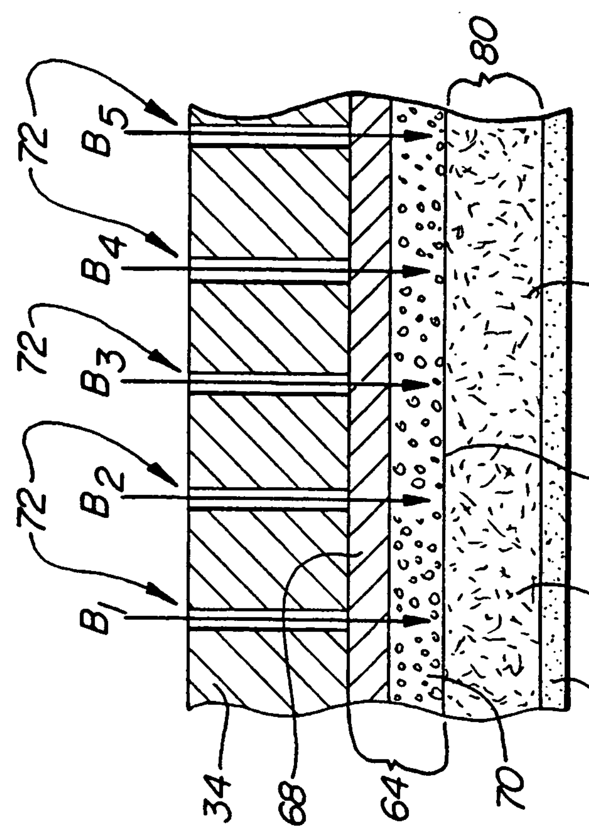


FIG-6

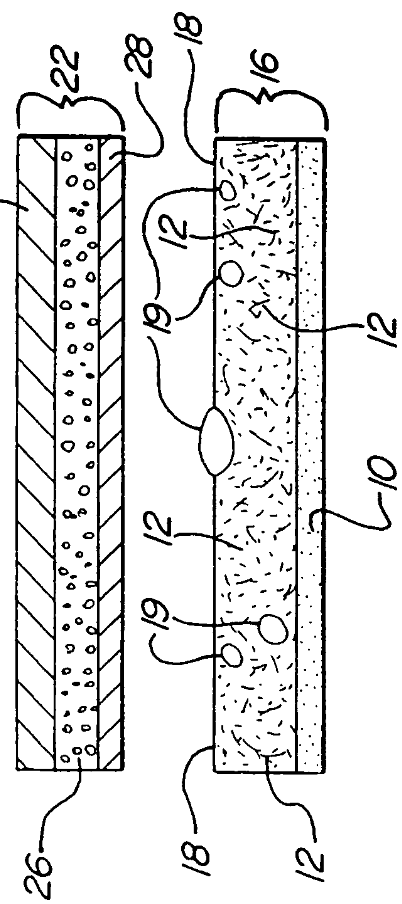


FIG-1
PRIOR ART

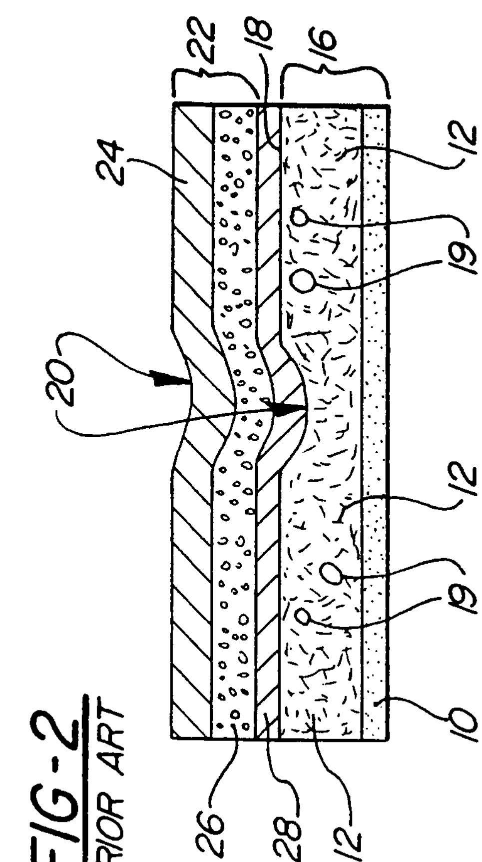


FIG-2
PRIOR ART

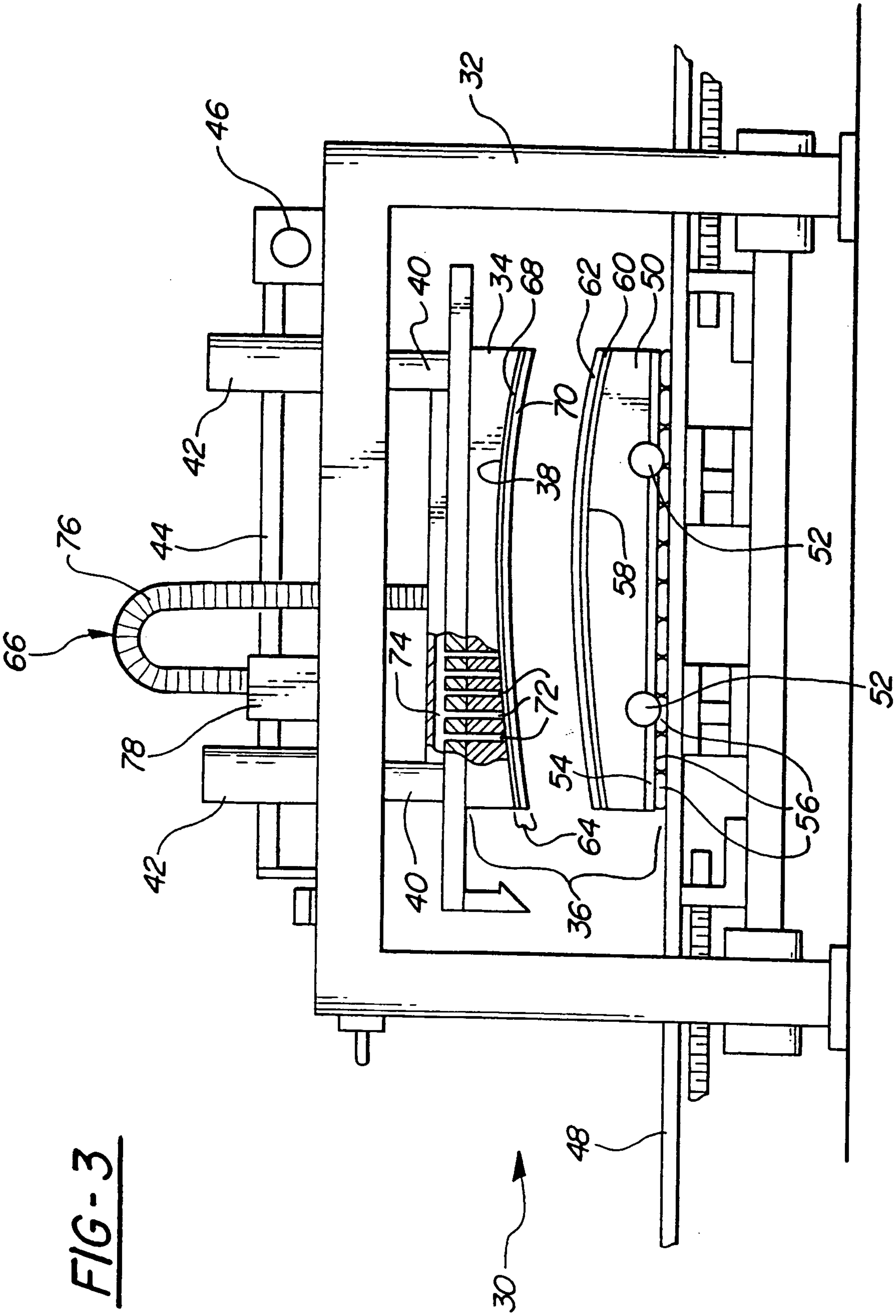
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FIG-3

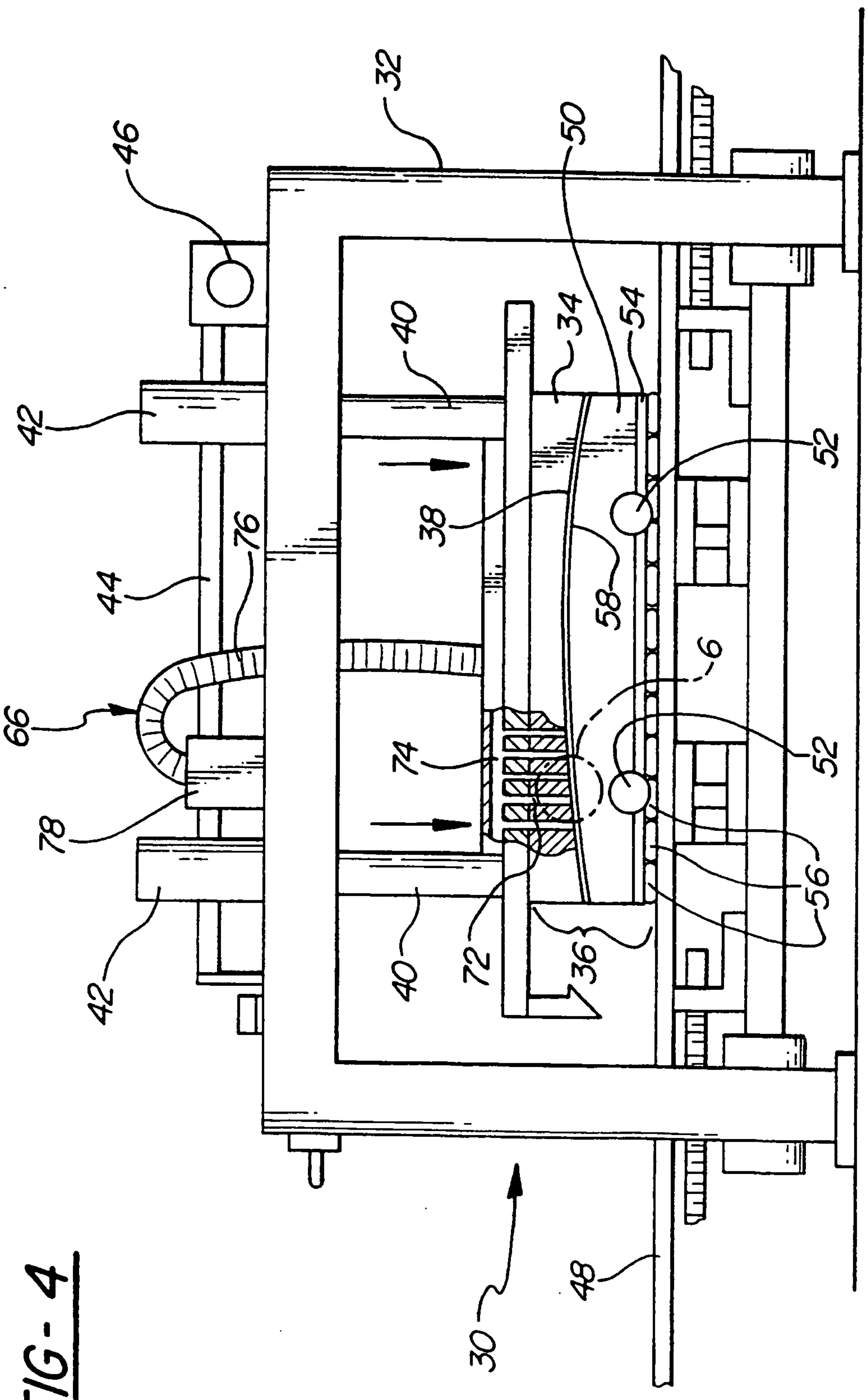


FIG- 4

# INTERNATIONAL SEARCH REPORT

Int ...tional Application No
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**A. CLASSIFICATION OF SUBJECT MATTER**
IPC 7 B60R13/02 B29C44/10 B29C44/58 B29C70/00

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B60R B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category ° | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
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| A | US 4 923 539 A (SPENGLER ERNST ET AL) 8 May 1990 (1990-05-08) claims 1,2,4; figures 4,6 | 1-6 |

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 22 February 2001 | 06/03/2001 |

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

Int  tional Application No
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